Teaching Science with Science Fiction

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Curriculum Unit Index

Overview

This curriculum unit is designed to focus on the use of science fiction material, both printed and audiovisual, to teach a number of required Pennsylvania State Standards for Science and Technology (1) in addition to a variety of concepts from the School District of Philadelphia's standardized curriculum for chemistry. With regard to the Planning and Scheduling Timeline for Chemistry (2), those units involving matter and energy, atomic structure, and chemical reactions will be of particular interest. The unit involving matter and energy is intended to examine changes that matter undergoes and the flow of energy through matter. Understanding the structure of the atom, as a means of understanding the makeup of matter, is the overall goal of the unit on atomic structure. As for the fundamental concept addressed in the unit on chemical reactions, it involves the ability of the students to predict the products of a chemical reaction based on a set of given reactants.

As envisioned, this will be an ongoing project throughout the academic year rather than limited to a short period of time. A portion of the unit will involve an interdisciplinary approach involving members of the English and science departments within Robert E. Lamberton High School. Therefore, the ultimate goal of this curriculum unit is to use science fiction as a pedagogical tool in motivating student interest in the sciences, and in particular chemistry. As motivational tools, the aims are quite clear. Their use in the classroom will serve to introduce specific topics, help motivate independent thought, and stimulate discussions on individual concepts. There are certain obstacles associated with the implementation of this project that need to be addressed. The use of novels throughout the unit, although highly desirable, may have to be limited due to budgetary constraints. The possibility exists that funding for class sets of books could come from the school's operating budget or from outside sources. Additionally, the ability to obtain class sets could be possible through the city of Philadelphia's Free Library system. At this point, however, the success of this project may have to rely heavily on the use of movie rentals.

Rationale

I have been a high school science teacher with the School District of Philadelphia for over twenty years. During that time, I have taught physical science, chemistry, biology, physics, environmental science, and applications of science and technology. For the past twelve years, I have been teaching at Robert E. Lamberton High School where I have witnessed changes in: administration, faculty, pedagogical strategies, demographics, and scholastic achievement. The focus of the school, however, has remained the same; an academic, college preparatory high school. Currently, I am teaching three chemistry classes to mostly eleventh grade students. The scholastic ability of the students varies widely with many students having deficiencies in both reading and math skills. This curriculum unit has been designed to serve as a motivational strategy in teaching a number of concepts and standards that would be in alignment with both the Pennsylvania State Standards for Science and Technology in addition to the School District of Philadelphia's standardized curriculum for chemistry.

It would be prudent, at this point, to briefly discuss the realm of science fiction since the term itself remains ambiguous. John Clute and Peter McNicholls devoted four pages in their <u>Encyclopedia of Science Fiction</u> to various definitions of this term (3). Not being able to agree on any acceptable definition has also left ambiguity as to its origin. Whereas some believe that science fiction had its beginnings with the ancient Sumerian <u>Epic of Gilgamesh</u>, others believe that it wasn't until the scientific discoveries in the seventeenth century that science fiction had its literary foundation. Prior to that time, Sir Thomas More's "<u>Utopia</u>", Sir Francis Bacon's <u>The New Atlantis</u>, and Johannes Kepler's <u>Somnium</u>, just to name a few, have been classified as proto-science fiction (4). In order to distinguish science fiction from proto-science fiction, Clute and McNicholls, state "Sf proper requires a consciousness of the scientific outlook, and it probably also requires a sense of possibilities of change, whether social or technological." Since this was not possible, to any great extent, until the nineteenth century, their belief is that Mary Shelley's gothic novel <u>Frankenstein</u> in 1818 was the first true example of science fiction literature (5).

As a literary genre, science fiction can be further classified into a number of subdivisions including: science, characteristics, movements, eras, and combinations. Of greater importance to this curriculum unit, is the distinction between hard science, soft science, and pseudoscience. Fictional material dealing with the quantitative principles and laws in disciplines such as, but not limited to, physics, chemistry, biology, astronomy, cosmology, and engineering are considered to be in the category of hard science fiction. In contrast, soft science fiction tends to involve many of the social sciences, such as anthropology, economics, psychology, and sociology. These areas deal more with areas that are difficult to quantify. Material classified as pseudoscience fiction involves scientifically unproven or erroneous ideas, such as astrology, and alternative medicine (6, 7). For the purpose of this unit, both hard and soft science fiction material will be considered useful.

The pedagogical use of science fiction as a motivational tool is not a new concept in education. In 1971, Dave Samuelson presented a proposal at the Sixty-first Annual Meeting of the National Council of English Teachers which called for "the mandatory use of science fiction in the general curriculum". Due to the interdisciplinary aspects inherent to science fiction, Samuelson believed that its use could lead to more flexibility in education (8). Additional credence to its use in the classroom was provided by Stephen Hawkins in the forward to The Physics of Star Trek. The world renowned astrophysicist wrote the following, "Science fiction like Star Trek is not only good fun but it also serves a serious purpose, that of expanding the human imagination. . . Science fiction suggests ideas that scientists incorporate into their theories, but sometimes science turns up notions that are stranger than any science fiction. . . Nevertheless, today's science fiction is often tomorrow's science fact" (9).

A common thread for the inclusion of science fiction into the curriculum, whether it is in the primary grades or at the post-secondary level, is the belief that it will improve scientific literacy. Since the late 1970's, Temple University has offered an undergraduate course for non-science majors which uses science fiction films to teach science. One of the goals of this project has been to examine the role science fiction films plays in reversing the negative attitudes of students towards science. It has been noted that a number of teachers who have taken the course have implemented this technique, with much success, in their classrooms from middle school up through high school (10). In a 2002 article which appeared in the Journal of Engineering Education, it was reported that Clark College which is affiliated with Washington State University offers a course entitled Engineering 280: Science Fiction in Engineering for freshman and sophomore students. The goal of which is to illustrate and teach basic concepts of engineering and physics with the aid of literature and movies (11). The California Department of Education, in 2007, has added the science fiction novel The Prometheus Project – Trapped to their recommended reading list for math and science (12). The Minister for Science Education in the United Kingdom suggested in August of 2007 that episodes of the popular science fiction television series Dr. Who might be used to teach science rather than "technical and boring textbooks" (13). Within the past year, the Massachusetts Institute of Technology (M.I.T.) used the film Jumper to stimulate discussions on the feasibility of quantum teleporting (14). It is quite apparent that the use of science fiction in the classroom is gaining more and more acceptance for a variety of reasons. Nevertheless, the judicious use of science fiction films must be considered, as was mentioned by Chandler Dennis. He reported two astute observations based on the use of science fiction films in his physics classes. Due to the attention span of his students, those observations included the use of films not more than fifteen years old, and showing only those movie clips which are relevant to the class, preferably ten minutes or less (15).

In 2001, Katherine T. Buchner and M. Lee Manning co-authored an article entitled "Taming the Alien Genre: Bringing Science Fiction into the Classroom". In that article the authors discuss the reluctance of teachers to introduce science fiction into the classroom. They concluded that this reluctance, by the teachers, is due in large part to being unfamiliar with science fiction materials and resources (16). David Brin, an accomplished science fiction writer with a background in astronomy and physics, wrote an article in which he outlined efforts which would foster the inclusion of science fiction into the classroom. The use of internet accessible resources for teachers was his first suggestion. His second major point was an invitation to other science fiction writers to create better reading material for students. His next point involved the outreach of local science fiction groups into the community to solicit support from school districts, teachers, parents, and organizations. In his final point, Brin discussed the use of mini-conferences between teachers and librarians (17). Another science fiction writer and a longtime proponent of the use of science fiction in the classroom, Julie Czerneda, wrote an article in which she stated, "A love of reading produces a person who is literate. A love of reading science fiction produces a literate person open to new ideas, critically aware of the consequences of change, and ready for the future.", In that article, Czerneda outlined a few meaningful activities that would be useful in incorporating science fiction into the classroom (18). These authors point out, what I believe, is the crux of the problem; teachers not only lack the time required in gathering suitable science fiction material but they also lack the time to incorporate it into their time restricted, mandated curriculum standards. For that reason, the remainder of this project will focus on resources that I plan to use throughout this unit and their relevance to both the Pennsylvania State Standards for Science and Technology as well as the School District of Philadelphia's standardized curriculum for chemistry.

Matter and energy is the first unit to be covered in the curriculum. A five week time frame has been allocated to cover: an exploration of matter, the changes it undergoes, energy flow, and measurement. Within this unit, emphasis is placed on: the different physical states and properties of matter, physical versus chemical changes, the relationship between matter and energy, exothermic and endothermic changes, the relationship between temperature and heat, in addition to the use of measurements and calculations in chemistry. The amount of useful science fiction material for this unit alone would need more time to cover than the five week time frame allocated by the school district. The following, however, is a short list of resources that could be used for this unit: H. G. Wells' <u>The Time Machine</u> (19), Brian Aldiss' <u>Hothouse</u> (20), David Brin's <u>Sundiver</u> (21), Lord Byron's poem "Darkness" (22) and <u>Star Trek</u> (23) the movie. The use of teleporting technology in H. G. Wells' <u>Time Machine</u> and the motion picture <u>Star Trek</u> would be employed in examining the relationship between matter and energy. In both, matter is converted into energy, transported through time and space and subsequently converted back to matter. This is an excellent introduction into the law of conservation of energy and matter. In presenting the relationship between heat and temperature, as well as exothermic and endothermic changes the science fiction subgenre of a dying Earth would be most useful.

The novels Hothouse, and Sundiver, along with the poem "Darkness", and the movie Sunshine all deal with the effects of a dying Sun. It is interesting to note that Lord Byron wrote "Darkness" in 1816 as the result of the eruption of Mount Tambora in Indonesia the previous year. The amount of volcanic ash in the atmosphere caused such abnormal climatic changes that it was referred to as "the year without summer" (24). The movie Star Trek would be used again, but this time to introduce scientific notation and dimensional analysis when addressing the topic of mathematics in chemistry. For calculating warp speed in this unit the equation used in the original Star Trek episodes will be used which is stated as follows:

$$S_w = w^3c$$

This differs from the equation used in *Star Trek: The Next Generation* series which was:

$$S_w = w^{10/3}c$$

S_w represents warp speed
w is the warp factor
c is the speed of light or 3.0×10^8 meters/second

For purposes of this curriculum unit, the first equation is preferable due to major discrepancies with the second equation as the warp factor increases (25). Using dimensional analysis, the students will be able to calculate not only speed but also the time, and distance traveled. Time will be calculated with respect to both conventional units as well as in light years using the conversion factor of:

$$1 \text{ light year} = 9.46 \times 10^{12} \text{ kilometers}$$

Students need to be reminded that speeds faster than the speed of light are not compatible with Einstein's theory of relativity and therefore are not attainable (26).

A four week time block has been allocated for the completion of unit two on atomic structure. Included in this unit is: the development of the atomic theory from ancient Greece up to and including the present day, the dual nature of light, and electron configuration notation. Although the unit begins with Democritus in ancient Greece, most of this section focuses on the scientific developments in the nineteenth and twentieth centuries. It was not until the very beginning of the nineteenth century that John Dalton proposed a model of the atom based on scientific evidence. Utilizing the law of conservation of mass, the law of definite proportions, and the law of multiple proportions Dalton was able to propose an atomic model based on the following four major points: matter is composed of individual particles or atoms, atoms of the same element are identical, the atoms of different elements are different in chemical properties and mass, and compounds are formed when atoms of different elements combine in definite proportions.

From this Dalton envisioned the atom as being a solid sphere that was indivisible and thus the smallest particle of matter (27).

It took nearly one hundred years before the first subatomic particle, the electron, was discovered by John Joseph Thomson. Since then, the work of Ernest Rutherford, Niels Bohr, James Chadwick, James Clerk Maxwell, Max Planck, Albert Einstein, Louis DeBroglie, Erwin Schrödinger, and Werner Heisenberg have led to the current model of the atom often referred to as the electron cloud model. With the aid of particle accelerators in the mid 1940's, numerous subatomic particles have been discovered. This has led to the branch of physics referred to as elementary particle physics whose principal aim is the study of nuclear structure. Although little attention is generally given to the field of elementary particle physics in traditional chemistry classes, I include a basic introduction in order to give a better understanding of subatomic particles and their role in the structure of the atom. For instance, I like to point out the differences in composition between protons and neutrons. The proton is composed of two up quarks and one down quark. The neutron, in comparison, is composed of two down quarks and one up quark. Whereas the up quarks have a +2/3 electrical charge, each down quark has a -1/3 electrical charge. Therefore, the overall composite charge of each proton is +1. This also explains the neutral charge for each neutron (28).

In describing the development of the atom, the characteristics and behavior of light are also studied. The controversy surrounding the nature of light began in the seventeenth century and centered on two physicists, one Dutch and the other English. The Dutch physicist, Christian Huygens, believed that light was composed of waves. The English physicist, Sir Isaac Newton, thought that light behaved as particles. This debate went on for approximately three hundred years. It was not until the early part of the twentieth century that the true nature of light was resolved. The current theory describes light as being made up of photons which travel through space as waves hence the name, the wave-particle theory of light (29).

Several interesting novels and movies could be used in this unit on atomic structure, quantum mechanics, and light. Among the novels are: Paul Preuss's Broken Symmetries, Gregory Benford's Matter's End, Greg Egan's Quarantine and Alfred Bester's The Pi Man (30). Topic appropriate movies could include: The China Syndrome (31), Jumper (32), and One (33). Any one of the first three novels and/or movies could be used to introduce subatomic particles and/or quantum mechanics. For example: Paul Preuss's 1983 science fiction novel Broken Symmetries, the storyline of which, involves a particle accelerator. Since a major theme in The Pi Man involves the electromagnetic spectrum, it would be useful for discussing the wave-particle characteristics of light.

Chemical reactions or unit six of the standardized curriculum is also scheduled to take four weeks to complete. This section has several goals. One of which is the ability of the students to identify and classify different types of chemical reactions. They include:

synthesis, decomposition, single displacement, double displacement, and combustion reactions. The students will also be expected to write both balanced and net ionic equations. In addition, they will also examine the absorption or release of energy during chemical reactions.

There are numerous literary and audiovisual science fiction resources that could be used for this particular section. Included in that rather long list are the following novels: Aldous Huxley's Brave New World, Robert Silverberg's The World Inside, and Marion Zimmer Bradley's Darkover Landfall (34). Movies to be considered are THX1138 (35), Equilibrium (36), and Minority Report (37). All of these representative resources have the use of mind altering or behavioral altering drugs intertwined throughout their individual storylines. Their use in this section will serve as a focal point for independent research by the students on neurotransmitters, such as: acetylcholine, dopamine, epinephrine, norepinephrine, serotonin, melatonin, and γ-aminobutyric acid (GABA). Dopamine, epinephrine, and norepinephrine are derivatives of the amino acid tyrosine. These naturally occurring compounds are associated with a variety of neurological and/or neuromuscular functions. Some of the more important neurophysiologic effects of these compounds include changes in mood, memory, and behavior (38, 39).

Objectives

This curriculum unit was developed with the specific intent of using science fiction literature and/or films as motivational tools in teaching chemistry. It is envisioned that theses resources will: improve scholastic performance, aid students in creative thought, encourage meaningful discussions, and stimulate interest in chemistry. A number of science fiction novels, poems and movies will be used teach a variety of standards and concepts throughout the academic year. These standards and concepts are in direct alignment with both the Pennsylvania Academic Standards for Science and Technology and the School District of Philadelphia's core curriculum for chemistry.

As designed, the curriculum unit is intended to address seven Pennsylvania Academic Standards for Science and Technology. They include the following standards: 3.1 E "Unifying Themes - describe patterns of change in nature, physical and man made systems", 3.4 A "Physical Science, Chemistry, and Physics - apply concepts about the structure and properties of matter", 3.4 B "Physical Science, Chemistry, and Physics - apply and analyze energy sources and conversions and their relationship to heat and temperature", 3.4 C "Physical Science, Chemistry, and Physics - distinguish among the principles of force and motion", 3.7 A "Technological Devices – apply advanced tools, materials, and techniques to answer complex questions", 3.7 B " Technological Devices – evaluate appropriate instruments and apparatus to accurately measure materials and processes", and 3.8 C "Science, Technology and Human Endeavors – evaluate possible consequences and impacts of scientific and technological solutions" (27, 28).

Strategies

In an ongoing effort to improve student achievement throughout the district, the School District of Philadelphia recently adopted an initiative for all high schools. The six step plan includes the following teaching strategies. With the first strategy, students are expected to preview content specific vocabulary on a daily basis. They are also expected to be able to preview, analyze, and connect material presented in textbooks. The remaining strategies include: reciprocal teaching, the ability to summarize material, the use of comprehension connectors or graphic organizers, and the ability to take notes. Since this curriculum unit is anticipated to be an ongoing project throughout the year, most if not all of these strategies will be used.

Parts of this unit will also necessitate the use of cooperative learning strategies which has been a successful pedagogical strategy for many years. The benefits of which have been shown to increase scholastic achievement, improve social skills, as well as team self-esteem. In order for cooperative learning to be an effective teaching strategy, deliberate care must be used in evaluating its ideal classroom design. There are six basic factors that one needs to consider in establishing and maintaining an effective cooperative learning environment. These factors include: team organization, cooperative management, the will to cooperate, the skill to cooperate, basic practices, and structuring the cooperative lesson. A synopsis of each will be presented in the presented in the following paragraphs (42).

From past experiences, team organization tends to be most effective when there is academic heterogeneity among the students rather than random selection. Academic heterogeneity allows for the establishment of teams or groups each of which contains students with high, average, and below average scholastic ability. Administering an entrance test the first week of school is extremely useful in this regard. Groups consisting of no more than four students have been ideal for a variety of reasons. Lateness and absences are real concerns for most of the high schools within the School District of Philadelphia. With four students in a group, individual groups can still function even when half of the students in any one group are absent. From the standpoint of classroom management, teacher determined learning groups tend to eliminate or diminish behavioral problems associated with those groups which were determined by the students.

Classroom management is essential to an effective cooperative learning environment. This can be accomplished through: cooperative management, the will to cooperate, and the skill to cooperate. It is imperative that students understand the guidelines for acceptable classroom behavior. For example, teachers must establish consistency in dealing with unacceptable noise level within the classroom. The will to cooperate is developed over time and is based on positive social interactions and pride within the group. The skill to cooperate is based on the ability of the students to assume specific roles within the group, listen to, and work with each other.

The basic practices inherent to cooperative learning include a number of behavioral skills which include: simultaneous interaction, positive interdependence, and individual accountability. Within a cooperative learning environment, the students are encouraged to interact with members within the group. This freedom is usually not permissible within a traditional classroom setting. Positive interdependence comes from the achievement of individual students within the group and from the entire group as a whole. Individual accountability can be addressed with the aid of a variety of assessments. For instance, students can be given individual grades for a project, or they can be made aware of their part of a group grade.

Effective classroom management depends, in large part, upon the structure of the lesson. Not only does it involve the arrangement of the students within the group, but it is also dependent upon the manner in which individual lessons are designed and presented. These structures, designs, or activities are meant to improve such areas as team building, information sharing, thinking skills, communication skills, and content mastery. A brief list of classroom structures and lesson designs include: brainstorming, jigsaw, numbered heads together, rally table, round robin, roundtable, student teams achievement division (STAD), team projects, and think pair share. A detailed review of each activity can be found in Cooperative Learning (30).

By improving their note taking skills, students should be able to utilize, practice, and/or engage in summarizing, comprehension connectors, and structured note taking. For those reasons, I intend to teach my students the highly successful method of note taking that was developed by Walter Pauk, an English professor at Cornell University in the 1950's. The Cornell Method, as it is referred to, involves writing a key word, phrase, or concept on the left hand side of a sheet of paper. In a column, on the right hand side of the sheet of paper, relevant material about the concept is written in short sentences or phrases. Finally, at the bottom of the page, the material listed is then summarized into a short paragraph. This widely used method enables students to improve their skills in summarizing material presented in both lecture and written form (31).

In order to address and improve reading comprehension, my students will participate in reciprocal teaching techniques. This is another cooperative learning activity which is designed to encompass four skills: summarizing, questioning, clarifying, and predicting. Each student within the group will be responsible for reading a specific section within their textbook or assigned reading material, summarizing that material, and reporting out to the rest of his or her group. This pedagogical strategy has been reported to be successful in both small groups as well as in large classroom settings (32).

Classroom Activities

Activity 1: Space Travel Math

The behavioral objectives for this activity include the students being able to improve their operational skills in solving mathematical calculations involving scientific notation and dimensional analysis. In this activity the students will be challenged to solve each of the following four problems. In doing so, each student should be able to demonstrate the four basic steps in solving word problems. They include: reading the problem, writing down the given information, finding an equation to solve the problem, and performing the mathematical operations as dictated by the equation. The students are required to show all work.

Problem 1:

In the television series, Star Trek, the teleporter on board the starship *Enterprise* was able to convert matter into energy and then back into matter. Using Einstein's mass-energy equivalence equation, $E = mc^2$, calculate the amount of energy generated in individually transporting two astronauts one weighing one hundred and fifty pounds and the other weighing one hundred and twenty pounds. As a reminder, 1 kilogram is equivalent to 2.2 pounds.

Problem 2:

An unmanned spacecraft is launched from the Kennedy Space Center in Florida. Its mission is to examine the outermost part of our galaxy. Determine the distance traveled by this spacecraft in one light year. Your answer must be in kilometers. The speed of light is 3.0×10^8 meters per second.

Problem 3:

Escape velocity refers to the minimum velocity required to leave the gravitational force of another object. Use the following equation: $v_{escape} = \sqrt{2GM/R}$ to determine the escape velocity of an unmanned spacecraft from each planet in m/s and km/s.

$G = 6.673 \times 10^{-11}$ Nm²/kg²

M = mass of the planet

R = the radius of the planet

Note: The students should convert the radius into meters prior to their calculations because of the units given for the universal gravitational constant, G.

Planet Name	Equatorial Diameter (km)	Mass (kg)	Escape Velocity (km/s)
Mercury	4 880	3.302×10^{23}	4.3
Venus	12 104	4.868×10^{24}	10.4
Earth	12 756	5.974×10^{24}	11.2
Mars	6 794	6.418×10^{23}	5.0
Jupiter	142 984	1.899×10^{27}	60.2

Saturn	120 536	5.685×10^{26}	35.5
Uranus	51 118	8.682×10^{25}	21.3
Neptune	49 528	1.024×10^{26}	23.5
Pluto	2 300	1.3×10^{22}	1.2

The physical data listed above was obtained from Universe seventh edition by Roger A. Freedman and William J. Kaufmann (33).

Problem 4:

Imagine that sometime in the future it becomes possible to travel at speeds greater than the speed of light. Determine the length of time it would take, in days, for three different spacecrafts to travel to Earth's nearest star Proxima Centauri which is 4.22 light years away. The three spacecrafts would be traveling at warp 2, warp 4, and warp 6 speeds respectively. For this exercise, assume the following equation in calculating the appropriate warp speed:

$$S_w = w^3 \times c$$

(S_w represents warp speed, w is the warp factor, and c is the speed of light 3.0×10^8 m/s)

Activity 2: Historical Events in Science

For this activity, the behavioral objectives include: explaining concepts relative to understanding the structure of matter, in addition to, describing different subatomic particles and their role in atomic structure. After reading Peter Preuss's novel Broken Symmetries and/or viewing the movie China Syndrome, the students, working cooperatively in groups, will research the scientific accomplishments which took place during the nineteenth and twentieth centuries. From the information gathered, each group will create a timeline on construction paper and report their findings to the rest of the class.

Activity 3: Power Point Presentation on Chemical Reactions of Neurotransmitters

This activity is a collaborative effort between the English and science departments. After either having read or seen the movie adaptation of Brave New World, students will work cooperatively in groups of four. Each group will be assigned an individual neurotransmitter that they are to research and create a power point presentation. It should include a brief history of the chemical, metabolic reactions, and psychological effects of the neurotransmitter. It should take approximately fifteen minutes to present in class. The list of neurotransmitters of interest include: acetylcholine, epinephrine, norepinephrine, dopamine, serotonin, melatonin, and γ-aminobutyric acid (GABA).

Annotated Bibliography/ Resources

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This reference guide details Pennsylvania's academic standards for science and technology for grades 9-12. It also addresses the assessment anchors and teaching strategies for each academic standard.

2. The School District of Philadelphia. Planning and Scheduling Timeline For Science: Grade 11 Chemistry. 2006.

Within this booklet, the School District of Philadelphia outlines the sequence of units to be covered, the time allocated for each unit, and the resources to be used in teaching each unit.

3. Clute, John and Nicholls, Peter, ed., The Encyclopedia of Science Fiction. New York: St. Martin's Griffin, 1993. 311-314.

John Clute and Peter Nicholls have compiled a wealth of knowledge dealing with the wide range of science fiction topics.

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John Clute and Peter Nicholls provide a detailed explanation of the differences between science fiction and proto-science fiction.

6. Clute and Nicholls, 968-971.

John Clute and Peter Nicholls extensively discuss the topic of pseudoscience giving numerous literary examples.

7. Science Fiction and Pseudoscience. Retrieved March, 2008 from <www.nsf.gov/statistics/seind02/c7/c7s5.htm>

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11. Segall, Albert E. “Science Fiction in the Engineering Classroom to Help Teach Basic Concepts and Promote the Profession.” March, 2008, <http://findarticles.com /p/articles/mi_qa3886/is_200210/ai_n9114535/print>
Segall explains the rationale for creating a science fiction course designed for freshman students at Clark College as a means of teaching common engineering concepts.

12. “The California Department of Education Adds Gripping Fiction Adventure, ‘The Prometheus Project – Trapped’,” to Its List of “Recommended Literature for Math and Science.” March, 2008, <http://findarticles.com/p/articles/mi pwwi/is_200711/ai_n21085332/print>
This press release by the publishers of “The Prometheus Project – Trapped” reported the decision by the California Department of Education to include Douglas E. Richards’ book on their recommended reading list in an effort to stimulate interest in science.

13. Gray, Richard “Doctor Who Can Help Save Science, Says Minister.” March, 2008, <http://www.telegraph.co.uk/news/uknews/1538785/Doctor-Who-can-help-save-science,-says-minister.html>
The Sunday Telegraph science reporter, Richard Gray, reported that the Minister of Energy, Malcolm Wicks, advocates the use episodes of the BBC television series Dr. Who and Star Wars films for teaching science to students in place of textbooks.

14. Overbye, Dennis “Quantum Teleporting, Yes; The Rest Is Magic.” March, 2008, <http://www.nytimes.co/2008/02/05/science/05mit.html>
In the article, two M.I.T physics professors together with the director and the star of

The science fiction movie Jumper discussed the physics of teleporting in the presence of an audience of M.I.T. students.

15. Chandler, Dennis M. "Start Using Hollywood Physics in Your Classroom." The Physics Teacher 40 (2002): 420-424.
The author of this article discusses the pedagogical use of science fiction videos in physics classes. He also mentions some very important considerations in keeping the students focused and

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The article discusses the circumstances which led Lord Byron to write this poem involving the death of the Sun and its consequences.

25. “Warp Drive,” Wikipedia [Web]. March, 2008, <http://en.wikipedia.org/wiki/Warp_drive>
Warp drive is discussed in detail.

26. Freedman, Roger A. and Kaufmann III, William J. Universe seventh edition. New York: W. H. Freeman and Company, 2005. 91-92.
This is an excellent cosmology textbook.

27. Myers, R. Thomas, Oldman, Keith B. and Tocci, Salvatore. Chemistry, Austin: Holt, Rinehart and Winston, 2004, 72-78.
This is the recommended textbook for the School District of Philadelphia’s standardized curriculum for chemistry.

28. Dorin, Henry, Demmin, Peter E., and Gabel, Dorothy L. Chemistry: The Study Of Matter fourth edition. Needham, MA: Prentice Hall, Inc. 1992, 109-145.
Dorin and his co-authors have presented a thorough account of the development of the structure of the atom.

29. Trinklein, Frederick E. Modern Physics, Austin: Holt, Rinehart and Winston, 1992, 280-314.
The controversy surrounding the nature of light is presented in an excellent manner.

30. Fraknoi, Andrew. “Science Fiction Stories with Good Astronomy & Physics: A Topical Index.” March, 2008, <http://www.astrosociety.org/education/resources/scifiprint.html>
This is an annotated list of novels and short stories that have relevance to a variety of topics dealing with astronomy and/or physics.

31. Clute and Nicholls, 217.
In The Encyclopedia of Science Fiction, Clute and Nicholls give a synopsis of the 1979 movie The China Syndrome.

32. Jumper. Liman, Doug, dir. Twentieth Century Fox. 2008. <http://www.imdb.com/title/tt0489099>
The website gives a brief summary of the movie’s plot.

33. One. Wong, James, dir. Revolution Studios. 2001. <http://www.imdb.com/title/tt0267804>

All of the pertinent information regarding the movie, including a plot synopsis, is given at this website.

34. Silverberg, Robert. Drug Themes In Science Fiction March, 2008, <http://www.erowid.org/library/library_bibliography1.pdf>
The pamphlet is an annotated list of science fiction literary resources that deal with the use of behavioral or mind altering drugs.

35. Clute and Nicholls, 1224.
The authors present a thorough synopsis of the film along with the role drugs played in the movie.

36. Equilibrium. Wimmer, Kurt dir. Dimension Films 2002. <http://www.imdb.com/title/tt0238380/>
The cast and a brief synopsis of the film is given at this website.

37. Minority Report. Spielberg, Stephen dir. Cruise/Wagner Productions. 2002. <http://imdb.com/title/tt0181689/>
This website gives information on the writers and cast while providing a synopsis of the film.

38. "Neurotransmitter," Wikipedia [Web]. April, 2008, <http://en.wikipedia.org/wiki/Neurotranmitters>
Types and effects of neurotransmitter systems are given.

39. "Neuromodulation," Wikipedia [Web]. April, 2008, <http://en.wikipedia.org/wiki/Neuromodulators>
Neuromodulation is explained briefly while providing the target sites for different neurotramitter systems.

40. Pennsylvania Department of Education. Pennsylvania Teacher's Desk Reference and Critical Thinking Guide, Jacksonville, FL: Educational Tools, Inc., 2006, 10-15.
This pamphlet details the Pennsylvania academic standards for science and technology for grades nine through twelve.

41. The School District of Philadelphia. Planning and Scheduling Timeline for Science: Grade 11 Chemistry. 2006.
The School District of Philadelphia outlines the sequence of units to be covered, the time allocated for each unit, and the resources to be used in teaching each unit.

42. Kagan, Spencer. Cooperative Learning. San Juan Capistrano, CA: Kagan Cooperative Learning, 1992. 4:1-4:9.

43. Kagan 7:1-8:2, 10:1-10:17.

44. "Cornell Notes," Wikipedia [Web]. April, 2007, <http://en.wikipedia.org/wiki/Cornell_Notes>
This article briefly explains the Cornell method.

45. North Carolina Regional Educational Laboratory. "Reciprocal Teaching," April, 2007, <http://www.ncrel.org/sdrs/areas/issues/students/atrisk/at6lk38.htm>
The benefits of reciprocal teaching are discussed as well as the steps involved.

46. Freedman and Kaufmann appendix 2.

Student Resources:

Freedman, Roger A. and Kaufmann III, William J. Universe seventh edition. New York: W. H. Freeman and Company, 2005.
This is an excellent resource for astronomy and cosmology. It will be particularly helpful for Activity 1: Space Travel Math.

Myers, R. Thomas, Oldham, Keith B., and Tocci, Salvatore. Chemistry, Austin: Holt, Rinehart, and Winston, 2004.
This is the recommended textbook for the chemistry course as assigned by the School District of Philadelphia.

Appendices-Content Standards

The Pennsylvania academic standards for science and technology, which will be addressed in this curriculum unit, were taken directly from the Pennsylvania Teacher's Desk Reference and Critical Thinking Guide (1) and include the following:

3.1.10 Unifying Themes: The unifying themes focus on the fundamental concepts and processes that form the framework upon which science and technology are organized, such as: the structure of matter.

E. Describe patterns of change in nature, physical and man made systems.
Describe how fundamental science and technology concepts are used to solve practical problems (e.g., momentum, Newton's law of universal gravitation, tectonics, conservation of mass and energy, cell theory, theory of evolution, atomic theory, theory of relativity, Pasteur's germ theory, relativity, heliocentric theory, gas laws, feedback systems).

3.4.10 Physical Science, Chemistry and Physics: Students study the relationship between matter, atomic structure and its activity.

A. Explain concepts about the structure and properties of matter.

Know that atoms are composed of even smaller sub-atomic structures whose properties are measureable.

Describe various types of chemical reactions by applying the laws of conservation of mass and energy.

B. Analyze energy sources and transfers of heat.

Evaluate energy changes in chemical reactions.

C. Distinguish among the principles of force and motion.

Describe light effects (e.g. Doppler effect, dispersion, absorption, emission spectra, polarization, interference).

Describe and measure the motion of sound, light and other objects.

Know Newton's laws of motion (including inertia, action and reaction) and gravity and apply them to solve problems related to forces and mass.

3.7.10 Technological Devices: Technology enhances the students' abilities to identify problems and determine solutions.

A. Identify and safely use a variety of tools, basic machines, materials and techniques to solve problems and answer questions.

Select and safely apply appropriate tools, materials and processes necessary to solve complex problems.

B. Apply appropriate instruments and apparatus to examine a variety of objects and. processes.

Compare and contrast different scientific measurement systems; select the best measurement system for a specific situation.

Apply accurate measurement knowledge to solve everyday problems.

3.8.10 Science, Technology and Human Endeavors: Scientific knowledge and societal needs often create a demand for new technology. Conversely, new technology advances scientific knowledge. Both influence society through the impact of their products and processes.

C. Evaluate possibilities, consequences and impacts of scientific and technological solutions.

Relate scientific and technological advancements in terms of cause and effect.

Analyze the impacts on society of accepting or rejecting scientific and technological advances.